Scientific Paper

Proximal composition and physical properties of fruits from seven *Morus alba* L. varieties▲

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Abstract

In Cuba many studies have been conducted about the use of different parts of the *Morus alba* plant in animal feeding. However, in these studies, the fruit has not been included. In international literature the *M. alba* fruits have been reported to show secondary metabolites and contain essential nutrients (fibers, vitamins and minerals), which increase their nutritional value and stimulate their use in balanced diets. The objective of this work was to determine the physical properties and bromatological composition of the fruits from seven *M. alba* varieties, cultivated at the Pastures and Forages Research Station Indio Hatuey. The weight, width, diameter and number of seeds per fruit were evaluated as physical indicators. In the proximal composition the dry matter, moisture and ash were studied, as well as calcium, magnesium, phosphorus and crude fiber. For the data processing a complete randomized design was used and variance analysis was performed. The fruit weight varied between 1,3 and 3,7 g; length, between 1,6 and 3,0 cm and width, between 0,8 and 1,6 cm. The number of seeds per fruit was 19,7-42,8. In the different varieties, the percentage of dry matter, moisture, crude fiber and ash was 13,5-17,5; 82,5-86,5; 8,1-12,7 and 3,6- 7,1 %, respectively. Meanwhile, the Ca, Mg and P content was in the range of 322,5-356,0; 176,5-201,0 and 40,5-52,5 mg/100 g, respectively. The variety Yu-62 showed the highest values in fruit weight, length and width, as well as in the dry matter and crude fiber content; while the variety Nueva had the highest P and ash content. Meanwhile, Universidad mejorada showed the highest Ca and Mg percentage.

Keywords: complementary feeding, chemical composition, diet

Introduction

The mulberry plant (*Morus alba* L.) is used in Chinese traditional medicine since ancient times, due to its chemical composition and pharmacological function. It belongs to the genus *Morus*, of the *Moraceae* family. It is a deciduous tree, of fast growth. Although it originated in Asia, because of its adaptation to different climate conditions, it is also found in temperate, subtropical and tropical regions of Asia, Europe, North and South America and Africa (Jiang and Nie, 2015).

Mulberry fruits are consumed fresh, dry, as jam, juices and liqueurs. They are also used in natural dyes and in the cosmetic industry (Imran *et al*., 2007). The caloric value of mulberry fruits is low, due to their scarce contribution of carbohydrates. They are rich in micronutrients (vitamin C) and bioactive compounds, such as organic acids, phenolic compounds, sugars and others (Sánchez-Salcedo *et al*., 2015). They also constitute a reserve of mineral salts.

At present, the search for natural sources is of high interest for their utilization as food complement and in the health industry. Regarding the latter, the benefits that are obtained from the consumption of fruits are due to their bioactive compounds, which play a beneficial function for the organism, the most important being those that have antioxidant effect (Gundogdu *et al*., 2011).

The objective of this study was to determine the physical properties and bromatological composition of the fruits from seven *M. alba* varieties.

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Materials and Methods

Location. The fruit samples were collected from the germplasm bank of the Pastures and Forages Research Station Indio Hatuey (EEPFIH) located at 22º 48' and 7'' North latitude and 79º 32' and 2'' West longitude, at 19 m.a.s.l., in the Perico municipality, Matanzas province, Cuba.

The soil of this region corresponds to the lixiviated Ferralitic Red type (Hernández *et al*., 2015). The topography is flat, with slope from 0,5 to 1,0 %. The average depth to the limestone is 1,50 m.

At the moment of collecting the fruits that were taken as sample, the mulberry was four years old, with planting density of 0,60 x 1,30 m.

Treatment and experimental design. A complete randomized design was applied and seven varieties, which constituted the treatments, were evaluated.

Experimental procedure. Regarding the plant material, for the trials fruits from seven mulberry varieties were used: Yu-12, Yu-62, Universidad, Acorazonada, Nueva, Cubana and Universidad mejorada.

The plants were randomly selected and the fruits were manually collected (1 kg) in the first hours of the morning, taking into consideration that they did not show physical damage and which were not contaminated by pathogens. They were put in polyethylene bags and were immediately transferred to the laboratory for their processing.

Physical properties. For each variety, 20 fruits were randomly taken and the weight, length, width, diameter and number of seeds per fruit were measured.

The weight (g) was determined in a Sartorius digital scale.

The length (cm) and width (cm) were measured with a ruler, and the diameter (cm) was determined with a caliper.

Each fruit was manually triturated to obtain the seeds and they were later counted.

Bromatological composition. A homogeneous 300-g sample of fruits was taken from each variety and sent to the Laboratory of Chemical Analysis of the EEPFIH in order to determine their proximal composition (dry matter, moisture, ash, calcium, magnesium, phosphorus and crude fiber), according to the techniques described by the AOAC (2000). For determining the sample weight, an analytical balance of the Sartorius commercial house was used.

Statistical analysis. A variance analysis (ANOVA) was performed for the data processing, after fulfilling the assumptions of variance homogeneity (Levene's test) and normality (Shapiro Wilk). The comparison among means was carried out through Duncan's multiple comparison test ($p \leq 0,05$) by the statistical package SSPS® Statistics 22.0.

Results and Discussion

The physical-chemical characterization allows to analyze the nutritional value and quality of fruits and vegetables. Table 1 shows the values of weight, length, width and number of seeds per fruit for each of the varieties. The fruit weight between 1,3 and 3,7 g; length, between 1,6 and 3,0 cm; and width between 0,8 and 1,6 cm. The number of seeds per fruit was between 19,7 and 42,8. The variety Yu-62 showed the highest values for all the studied variables; while Acorazonada had the lowest ones.

Regarding the physical-chemical characterization of the mulberry fruits, Sánchez-Salcedo *et al*.

Table 1. Weight, length, width and number of seeds/fruit of seven *M. alba* varieties.

Variety	Mean ± SE			
	Weight, g	Length, cm	Width, cm	Number of seeds /fruit
Yu-12	$2,8 \pm 0,147^{b}$	$2,7 \pm 0,147^{a,b}$	$1,2 \pm 0,074^{b}$	$39,8 \pm 0,003^{a,b}$
Yu-62	$3,7 \pm 0,155^{a}$	$3,0 \pm 0,153^{a}$	$1,6 \pm 0,103^{a}$	$42,8 \pm 0,002^{a}$
Universidad	$2,7 \pm 0,123^{b}$	$2,7 \pm 0,043^{a,b}$	$1,2 \pm 0,043^{b}$	$39,9 \pm 0,002^{a,b}$
Acorazonada	$1,3 \pm 0,086^{d}$	$1,6 \pm 0,074^{d}$	$0,8 \pm 0,037^{c}$	$19,7 \pm 0,003^{c}$
Cubana	$2,2 \pm 0,069^{c}$	$2,1 \pm 0,067^{c}$	$1,1 \pm 0,033^{b}$	$20,3 \pm 0,002^{b}$
Nueva	$2,7 \pm 0,166^{b,c}$	$2,8 \pm 0,088^{a}$	$1,3 \pm 0,035^{b}$	$38,4 \pm 0,002^{a}$
Universidad Mejorada	$2,8 \pm 0,081^{b}$	$2,4 \pm 0,068^{b,c}$	$1,2 \pm 0,039^{b}$	$23,1 \pm 0,003^{c}$

a, b, c, d: Values with different superscripts in each row differ at $p < 0,05$

(2014), in a study conducted in Spain with different clones, reported that the weight of the mulberry fruits varied between 2,3 and 4,2 g; diameter, between 1,3 and 1,6 cm, and length, between 2,0 and 3,0 cm.

Jiang and Nie (2015) analyzed the physical-chemical properties of the mulberry fruits (*M. alba*, *M. alba var. tatarica* and *Morus nigra* L) in the Chinese province of Xinjiang. These authors found that the *M. alba* fruits showed the highest weight with regards to the other varieties, being higher than 3,5 g. This value is slightly lower than the one reported in studies conducted in other regions of China, in which the variation of the fruit weight was between 1,3 and 4,8 g (Liang *et al*., 2012).

Altuntas (2016) conducted a study of the volumetric and geometric properties of the *M. alba* fruits in Tokat, Turkey. This author obtained values of 1,1 g; 1,6 and 1,0 cm for the fruit weight, length and width, respectively.

In an evaluation of the nutraceutical potential of some fruits in Sikkim, Himalaya and India, Bhutia *et al*. (2018) reported that the *M. alba* fruits showed weight, length and width of 3,47 g, 2,5 and 1,3 cm, respectively, with abundant quantity of seeds per fruit. These results coincide with the ones obtained in this research for the *M. alba* varieties.

It is stated that the physical properties can vary, when the plant materials are different and because of the influence of the climate and nutritional conditions to which the plant material is exposed (Imran *et al*., 2010). In this study, the differences in the physical properties are due to the fact that different varieties were analyzed, because the other conditions were homogeneous.

As part of the proximal analysis (table 2), the percentage of dry matter, moisture and crude fiber of the different varieties showed significant differences for $p < 0,05$. The values varied between 13,5-17,5; 82,5-86,5 and 8,1-12,7 %, respectively.

Yu-62 showed higher dry matter and crude fiber content and lower moisture; while the variety Nueva reached the lowest dry matter percentage and, thus, the highest moisture content. Universidad mejorada had less crude fiber.

In this research, the maximum values were slightly higher than the ones reported by Imran *et al*. (2010) for four *M. alba* species from Pakistan. The moisture and crude fiber content varied between 79,0-82,4 and 0,6-11,8 %, respectively. This difference is ascribed to the fact that they were different species. Nevertheless, these results are in correspondence with those obtained by Liang e*t al*. (2012) in mulberry cultivars in Jiangsu, China, and with the report by Sánchez-Salcedo *et al*. (2013) for different mulberry clones, in Spain.

Regarding the minerals, the ash content was 3,6-7,1 %. The calcium, magnesium and phosphorus content was 322,5-356,0; 176,5-201,0 and 40,5-52,5 mg/100 g, respectively (table 3). The variety Nueva showed higher phosphorus and ash content. Universidad Mejorada had the highest calcium and magnesium percentage, both with significant differences compared with the others.

The ash content was in correspondence with the report by Liang *et al*. (2012) in a study conducted for mulberry cultivars in Jiangsu, China. These authors referred values between 3,5 and 6,6 %. They are similar to the ones obtained by Lee and Hwang (2017), who described that the ash content varied between 4,3 and 8,3 %, and decreased with the increase of the maturation of *M. alba* fruits in a region of Korea.

Regarding the calcium and magnesium content, in this study, the results were higher than those obtained by Jiang and Nie (2015) and Lee and Hwang

Table 2. Dry matter, moisture and crude fiber in fruits from seven *M. alba* varieties (%).

Variety	Mean ± SE		
	Dry matter	Moisture	Crude fiber
Yu-12	$15,4 \pm 0,024^{d}$	$84,6 \pm 0,024^{c}$	$9,7 \pm 0,047^{c}$
Yu-62	$17,5 \pm 0,010^{a}$	$82,5 \pm 0,010^{f}$	$12,7 \pm 0,039^{a}$
Universidad	$13,8 \pm 0,036^{e}$	$86,2 \pm 0,036^{b}$	$9,6 \pm 0,025^{d}$
Acorazonada	$17,0 \pm 0,067^{b}$	$83,0 \pm 0,067^{e}$	$9,4 \pm 0,017^{e}$
Cubana	$15,8 \pm 0,061^{c}$	$84,2 \pm 0,061^{d}$	$9,9 \pm 0,013^{b}$
Nueva	$13,5 \pm 0,069^{f}$	$86,5 \pm 0,069^{a}$	$8,7 \pm 0,008^{f}$
Universidad mejorada	$13,8 \pm 0,184^{e,f}$	$86,3 \pm 0,184^{a,b}$	$8,1 \pm 0,018^{g}$

a, b, c, d, e, f: Values with different superscripts in each row differ at $p < 0,05$

Table 3. Content of ash, Ca, Mg and P in fruits from seven *M. alba* varieties.

Variety	Mean ± SE			
	Ash, %	Ca, mg/100g	Mg, mg/100g	P, mg/100g
Yu-12	5,0 ± 0,031[c]	349,0 ± 0,015 [b]	187,0 ± 0,015[d]	46,5± 0,010[c,d]
Yu-62	4,7 ± 0,011[d]	341,0 ± 0,008[b]	185,0 ± 0,005[d]	48,0 ± 0,004[b,c]
Universidad	5,4 ± 0,022[b]	332,0 ± 0,059[e]	181,0 ± 0,005[e]	46,0 ± 0,002[c]
Acorazonada	5,3 ± 0,046[b]	322,5 ± 0,007[d]	176,5 ± 0,008[f]	49,5 ± 0,004[b]
Cubana	4,5 ± 0,131[e]	345,0 ± 0,009 [b]	191,0 ± 0,005[c]	46,5 ± 0,005[c,d]
Nueva	7,1 ± 0,047[a]	345,0 ± 0,009 [b]	195,0 ± 0,006[b]	52,5 ± 0,006[a]
Universidad mejorada	3,6 ± 0,023[f]	356,5 ± 0,006[a]	201,0 ± 0,005[a]	40,5 ± 0,003[e]

a, b, c, d, e, f: Values with different superscripts in each row differ at $p < 0,05$

(2017). However, they are in correspondence with the ones reported by Sánchez-Salcedo *et al*. (2015), who reported that the Ca and Mg values varied between 190-340 and 120-190 mg/100 g respectively, for different clones of this species in Spain.

The phosphorus content was lower than the one referred by Sánchez-Salcedo *et al*. (2015), but it is in correspondence with the report by Nurhan *et al*. (2017) in studies with *M. alba* fruits in two regions of Turkey.

The mineral composition of the fruits depends not only on the species or varieties, but on the growth conditions, soil status and geographical characteristics. In this study, predominance of Ca, followed by Mg and P was followed. The presence of these minerals turns mulberry fruits into a valuable horticultural product due to their rich nutritional composition, which is very beneficial, for which the inclusion of these fruits in any type of diet can be considered (Rodrigues *et al*., 2019).

Conclusions

The variety Yu-62 showed the highest values in fruit weight, length and width, as well as in the dry matter and crude fiber content; while the variety Nueva reached the highest P and ash content. Meanwhile, Universidad mejorada showed the highest Ca and Mg percentage.

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